

Space Weather and Launch Vehicles

Antares



Soyuz



Ariane 5



Atlas V



Vulcan



Falcon 9



Falcon Heavy



Delta IV Heavy



New Glenn 2-stage



New Glenn 3-stage



New Glenn Landed Booster



Saturn V



Who am I?

❑ Ben Griffiths

- 10 Years with United Launch Alliance
- Currently at Ball Aerospace
- Radiation Effects / Systems Engineer at both companies

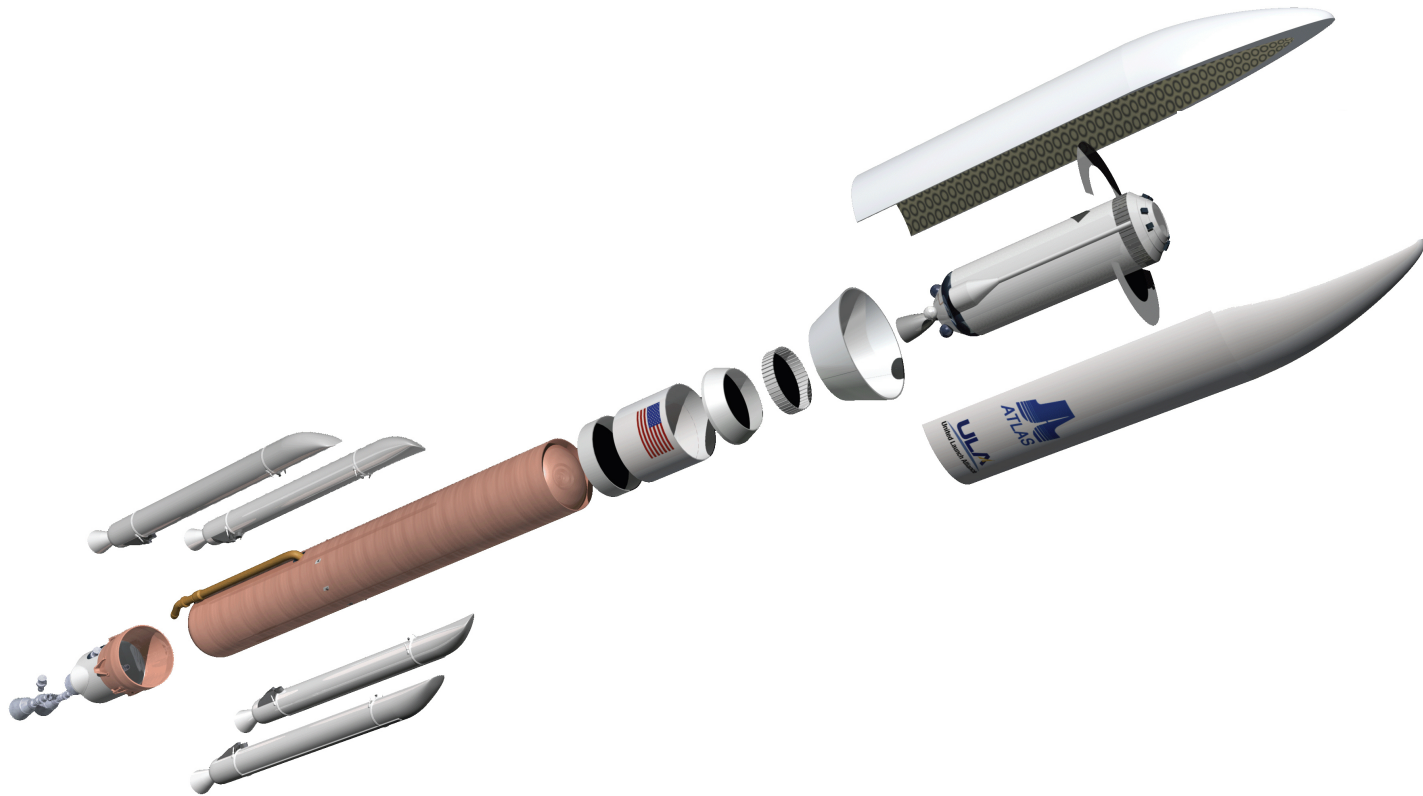
❑ Standard Disclaimer

- I am speaking from personal knowledge of this subject and my views do not represent any company that I currently or have previously worked for.



Launch Vehicle Picture

❑ “Expanded” View

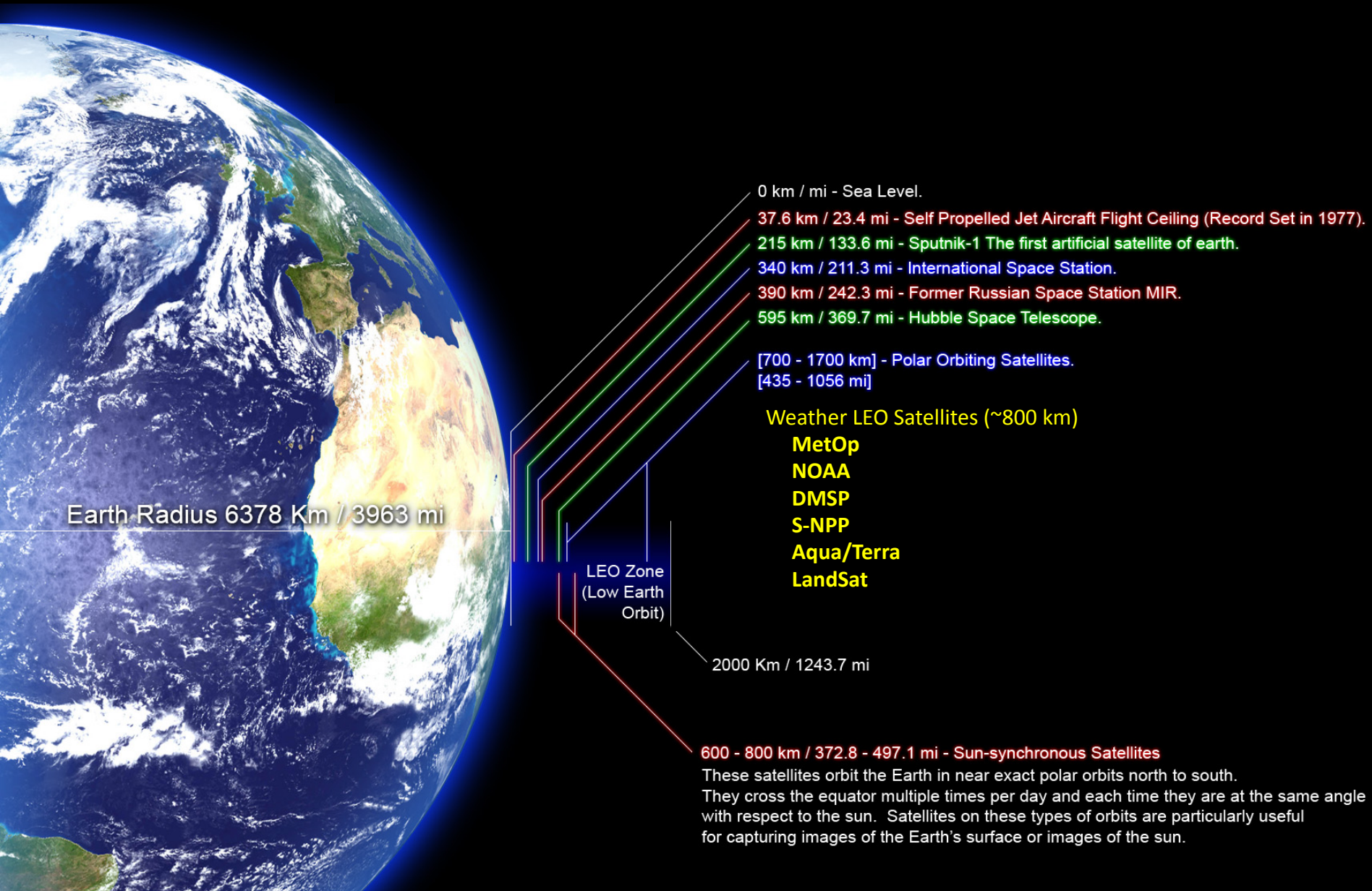


The Three Main Issues With Space Weather

- ❑ Three main issues arise (or will soon) with Launch Vehicle electronics because of the space environment
 - Single Event Effects (SEE)
 - Disruption or destruction caused by the passage of a single heavy ion through sensitive regions of electronic piece parts
 - Total Ionizing Dose (TID)
 - Caused by energy deposited by ionization process in the target material
 - Displacement Damage Dose (DDD)
 - Displacement of atoms from the lattice of the target material
- ❑ What causes the above issues? Solar Weather
 - Van Allen Belts
 - Galactic Cosmic Rays
 - Atmospheric Neutrons
 - Electron Belts
 - Solar Flares

Orbital Types

Low Earth Orbits (LEO)



Orbital Types

Medium Earth Orbits (MEO)



Earth Radius 6378 Km / 3960 mi

0 km / mi - Sea Level.
37.6 km / 23.4 mi - Self Propelled Jet Aircraft Flight Ceiling (Record Set in 1977).
215 km / 133.6 mi - Sputnik-1 The first artificial satellite of earth.
340 km / 211.3 mi - International Space Station.
380 km / 242.3 mi - Former Russian Space Station MIR.
595 km / 369.7 mi - Hubble Space Telescope.
[700 - 1700 km] - Polar Orbiting Satellites.
[435 - 1056 mi]

LEO Zone
(Low Earth
Orbit)

MEO Zone
(Medium Earth Orbit)

2000 Km / 1243.7 mi

600 - 800 km / 372.8 - 497.1 mi - Sun-synchronous Satellites
These satellites orbit the Earth in near exact polar orbits north to south.
They cross the equator multiple times per day and each time they are at the same angle
with respect to the sun. Satellites on these types of orbits are particularly useful
for capturing images of the Earth's surface or images of the sun.

MEO Satellites (1000-30,000 km)
GPS

35,786 km
Geosynchronous (GEO) and Geostationary (GSO)
Geosynchronous satellites orbit the Earth at the same rate as the Earth rotates. Thus they remain stationary over a fixed location on the Earth's surface.
A geostationary satellite will remain in a fixed location relative to the Earth's surface, allowing a satellite dish to be pointed at a fixed angle to receive transmissions from the satellite.
This particular altitude marks the border between the LEO and GEO Zones.

Orbital Types

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GEO Weather (~36,000 km)
GOES (Americas)
MSG (Europe)
Himawari (Japan)

Ground trace is stationary:
Satellite orbits at same rate as earth turns
(24-hr orbit)

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a fixed locati
tellite dish to
ler between it

HE
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Orbital Types

And where is the Moon?

LEO
(<1000 km)

GEO
(~36,000 km)

Moon
(384,000 km)

Scale: 1 Pixel = 100 Km / 62.1 mi

20000 km / 12437.4 mi

MEO Zone
(Medium Earth Orbit)

HEO Zone
(High Earth Orbit)

LEO Zone
(Low Earth Orbit)

384,000 km
The Moon

MEO **Supersynchronous orbit**
(1,000-10,000 km) (> 36,000 km)

Where are we today?

- ❑ The vast majority of launches today are very short
 - 30 min - a few hours
 - RARELY half a day
 - Single-use upper stage
 - SEE are the primary concern

- ❑ Requirements do exist for Space Weather and Launch Commit Criteria
 - Early stages of satellite deployment
 - Space charging
 - Increased SEE

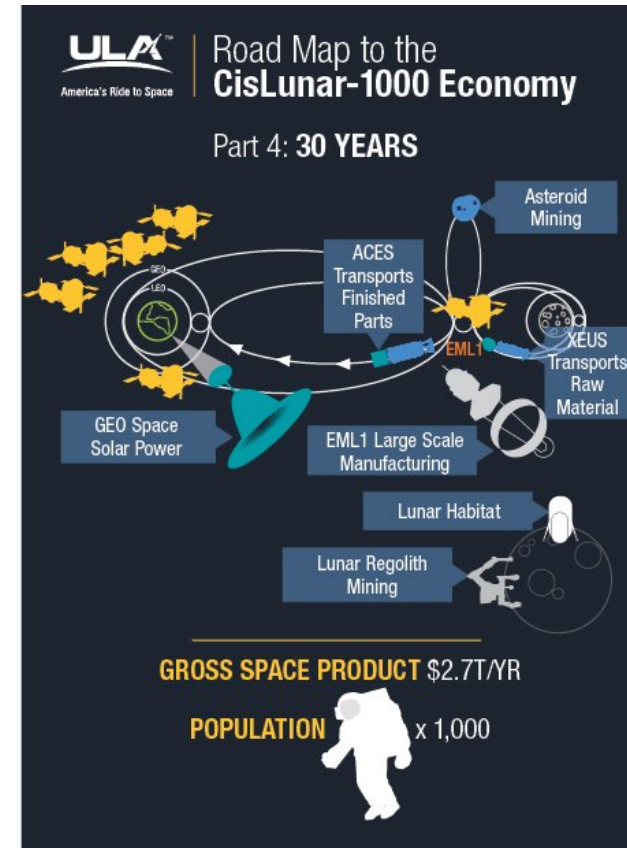
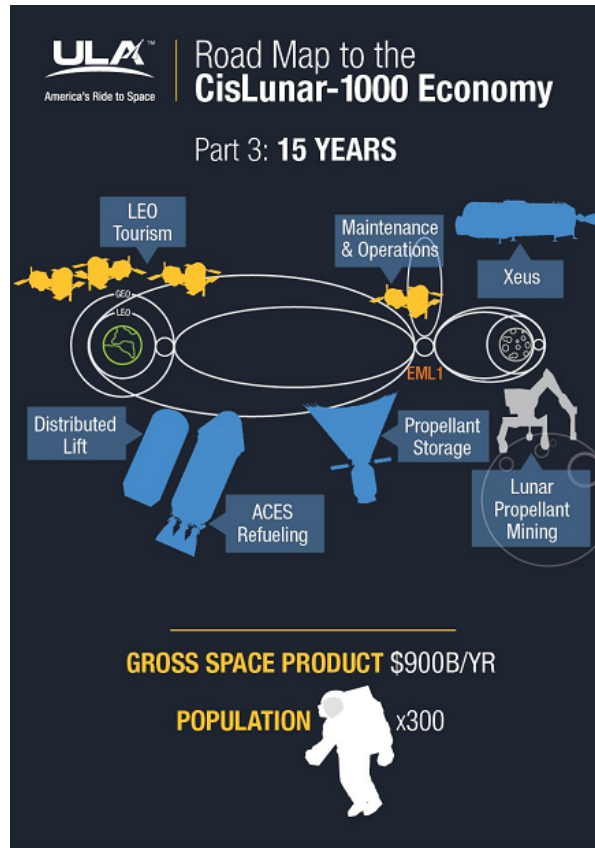
Where are we going?

Longer and Longer Missions

- Cis-Lunar 1000
- Multi-use upper stages
- Moon
- Mars
- Astroids
- Blurring of the line between Launch Vehicles and Satellites

More missions at lower costs

- More commercial-like parts
- Smaller part features
- Less margin



All add up to greater impacts from space weather.